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Gamma-Gamma Interaction Region Design Issues

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Gamma-Gamma Interaction Region Design Issues

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Abstract. An initial design of the optics required for producing gamma-gamma collisions was produced for the NLC Zeroth Order Design Report (ZDR) submitted to the 1996 Snowmass workshop. The design incorporated only loose constraints from the interaction region requirements. In this paper we report progress on a design of a gamma-gamma interaction region which incorporates all constraints.

INTRODUCTION

High energy photons can be produced through Compton scattering when high energy electrons are collided with a pulse of laser photons [1]. The high energy photons follow the direction of the lepton and can therefore be focused down to a spot at the interaction point (IP) providing a large rate of gamma-gamma collisions.

A gamma-gamma interaction region (IR) is similar to an e^+e^- IR with the addition of optics to transport laser pulses into the IR and focus them to a diffraction limited spot a few millimeters before the IP. After the conversion point (CP) the incoming bunch contains a mix of high energy photons, UN-scattered high energy electrons, and low energy scattered electrons. When these bunches reach the IP $\gamma\gamma$, $e\gamma$ and ee luminosities are generated and the charged particles in the bunch are deflected by the beam-beam interaction. These particles must then be transported out of the IR to a beam dump where their energy is dissipated.

OPTICS

The optics design [2] produced for the NLC Zeroth Order Design Report (ZDR) is shown in Figure 1. A four mirror telescope focuses a laser pulse at the first CP then the pulse is reflected back and focused to the second CP using a complementary four mirror telescope on the other side of the IP. The optics design assumed that

[1] This work was performed under the auspices of the U.S. Department of Energy by the University of California, Lawrence Livermore National Laboratory under Contract No. W-7405-Eng-48.

the available space was defined by the front face of the final quadrupole at 2 meters and a cone of 135 milliradians from the IP. Recent IR designs have moved the final quadrupole back to 4.3 meters and narrowed the cone to 80 milliradians.

In Figure 2, we show the modification to the mirror placement and the IR that are envisioned for the gamma-gamma IR. The final focus mirror has been pulled back and it's radius is enlarged. Where the original mirror design included two holes to allow the incoming and outgoing beams to pass, the current design has one large hole. This is an improved design for achieving a diffraction limited spot and also allows the beam backgrounds produced at the IP to avoid showering in the mirror.

OUTGOING BEAM LINE AND BEAM DUMP

The beam dump must be able to both dissipate the full beam power and its vacuum window must survive the passage of the beam. The ZDR [2] design assumed a 10 MW beam of charged particles that was focused to an RMS spot size of 0.5 mm. In a gamma-gamma collider the high energy photons are produced with the angular spread of the incoming electron beam, typically 30 microradians. At the beam dump they have an RMS spot size of 4.5 mm. Since the photons do not deposit any energy until they convert to an e^+e^- pair and the spot size is larger there should not be a problem with the vacuum window.

The deflection of charged particles by the oncoming bunch results in an angular distribution of the particles which extends to ± 5 milliradians, as simulated with the CAIN [3] program. As can be seen in Figure 2, the extraction line has been enlarged to ± 10 milliradians to accommodate these charged particles. In order to avoid a conflict between the extraction line and the final quadrupole, the crossing

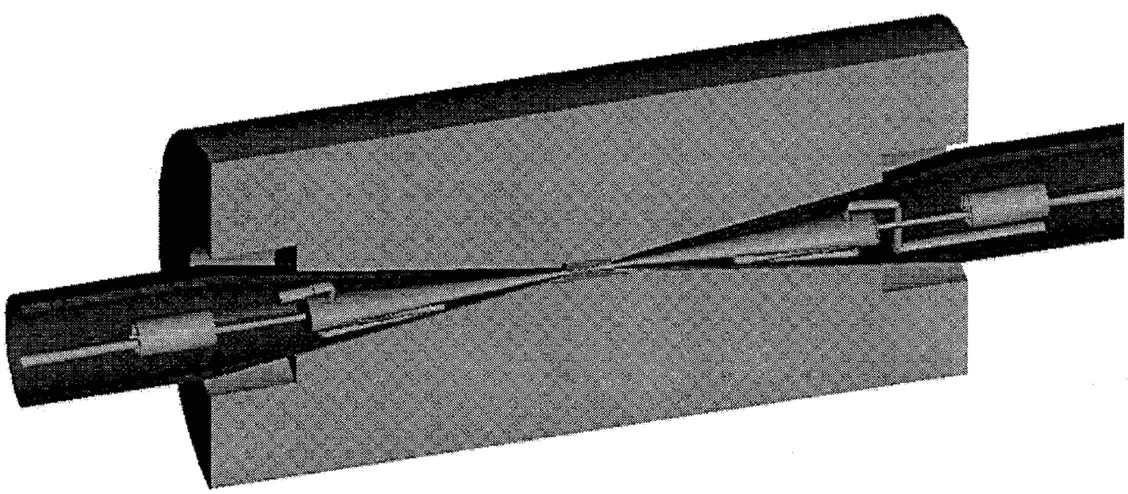

FIGURE 1. The layout of the interaction region assumed for the ZDR.

angle has been increased to 30 milliradians although with clever engineering this could be reduced back to 20 milliradians.

Additionally, the charged particles spiral in the solenoidal magnetic field of the detector. Figure 3 shows the particle's position in y and the direction cosine in y at z equals 4 meters, assuming a 4 Tesla magnetic field. No particles have escaped the extraction line aperture at that point but a few particles no longer point to the beam dump. Their effect on backgrounds in the IR and the extraction line tunnel remain to be determined.

CONCLUSIONS

The optical design for focusing laser pulses that was made for the ZDR is now being updated to include real interaction region constraints. First studies show that the optics can be accommodated without a serious impact on the detector. The extraction line and beam dump will need to be modified to handle outgoing particle distributions that are different from the e^+e^- case.

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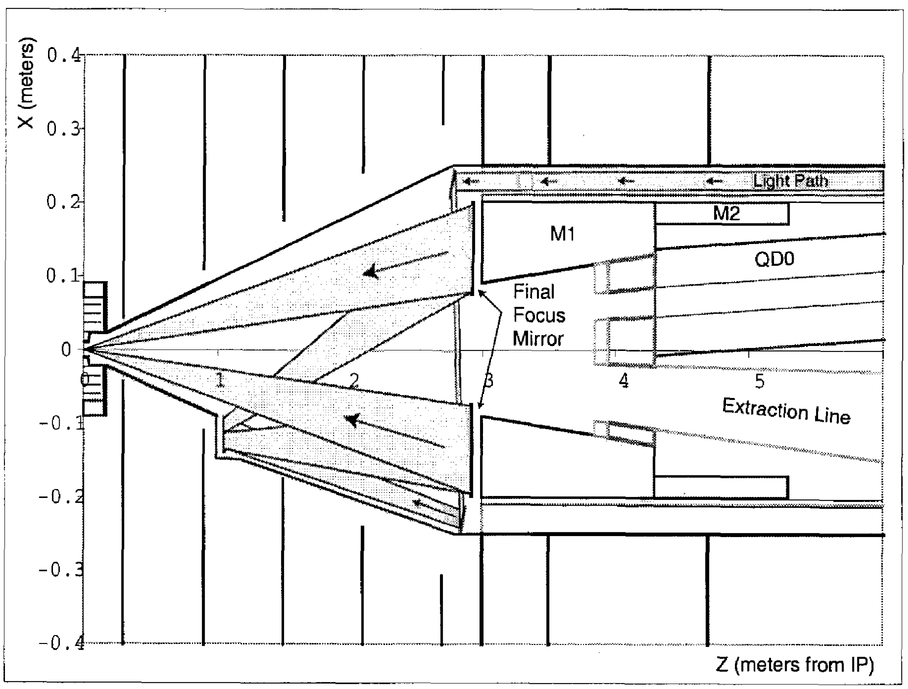

FIGURE 2. The new layout of the mirrors and the modified interaction region.

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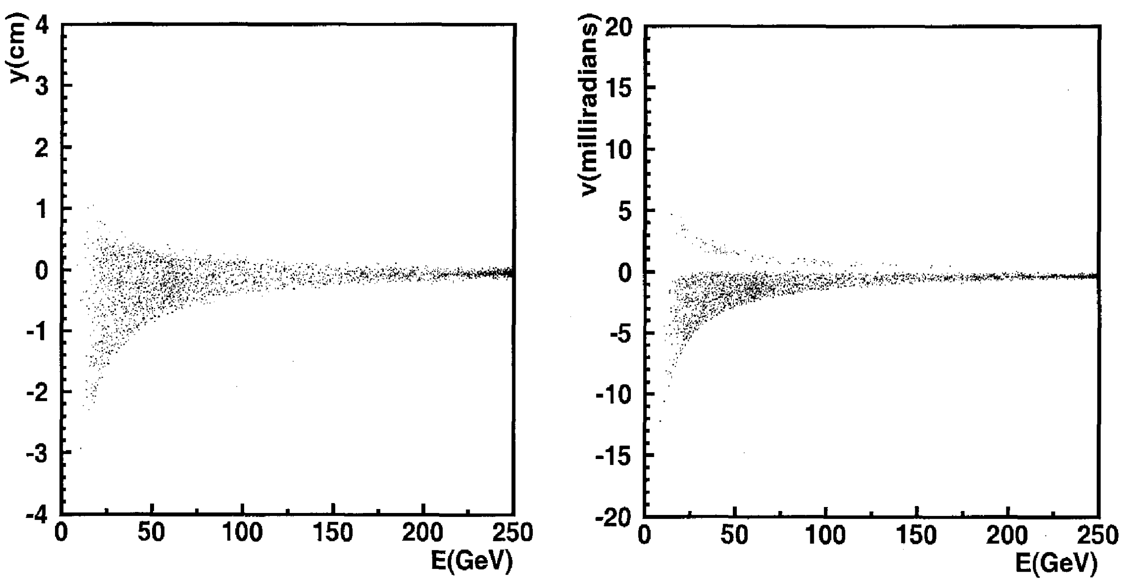

FIGURE 3. The deflection of the outgoing charged particle by the solenoidal magnetic field as a function of energy. In the second figure the less populated upper band is positrons from $\gamma\gamma \rightarrow e^+e^-$. The low energy cutoff in charged particle energy is a feature of Compton scattering.